Statement (FEIS) for Designation of a Deep Water Ocean Dredged Material Disposal Site off San Francisco, California (USEPA 1993a). Extensive supporting reference material is cited in that document.

4.5.2.1 Physical Oceanography

Three distinct areas or zone have been identified in the offshore water column, or "pelagic" zone. The upper area of the open ocean (surface to 200 m deep), called the epipelagic zone, is the region in which light penetrates. It is warmer, richer in oxygen, and better mixed than deeper strata. In the mesopelagic zone, which ranges in depths from 200 to 1,000 m, light rapidly decreases as does temperature and oxygen, while pressure increases rapidly. Within the mesopelagic zone is a region called the Oxygen Minimum Zone (OMZ) where oxygen concentrations are the lowest in the entire water column. This phenomenon usually occurs at depths between 500 to 900 m and is an area where species diversity is low. The bathypelagic zone is located below 1,000 m and is characterized by complete darkness, low temperature, low oxygen, and great pressure. Each of these zones are used by different assemblages of species.

Physical oceanographic parameters that are important for evaluation of dredged material disposal are wind and current patterns, waves, and tides.

Wind and Current Patterns

Winds are important in determining current patterns along the continental shelf and upper continental slope near the Farallon Islands. Typically, strong northerly and northwesterly (i.e., directed toward the south and southwest, respectively) winds predominate during the spring and summer. These winds, coupled with the Coriolis Force caused by the Earth's rotation, induce a seaward-directed flow of surface waters that results in upwelling of colder, saline, nutrient-rich waters over the slope and in the vicinity of the shelf break. In contrast, winds are more variable during the fall and winter, and upwelling then is generally absent. These wind and current patterns are described in more detail below.

The Gulf of the Farallones continental shelf and slope areas are located within the California Current system, an eastern boundary current that forms the eastern portion of the North Pacific subtropical gyre. The California Current is a broad offshore flow that transports cold, low salinity, subarctic waters equatorward. However, because of the proximity of Point Reyes, two poleward flows — the Coastal Countercurrent and the California Undercurrent — dominate the flow regime in the vicinity of the Farallon Islands throughout most of the year. The Coastal Countercurrent generally moves nutrient-poor, surface water over the continental shelf northward. This current is especially strong during the winter months (October to February, when the northerly — or equatorward — winds are weakened). The California Undercurrent is a strong poleward flow over the slope that dominates in depths ranging from 100 to 1,000 meters.

During the spring and summer in most years, the strength and offshore range of the Coastal Countercurrent is reduced as a result of northerly (equatorward) winds. This condition favors the upward movement of nutrient-rich water from the continental slope onto the continental shelf, known as "upwelling." During upwelling, the influx of nutrients into coastal waters greatly increases the production of food for many marine organisms.

The seasonal patterns in the large-scale surface (upper 250 m) currents generally are divided into two seasons: an upwelling period from March to August; and the winter period from October to February. September is a transition month and may be more like one season or the other depending on the year.

The spring and summer upwelling season is characterized by fluctuating flows with a net southward component. An "upwelling front" forms between the upwelled water and the warmer, less dense water farther offshore. Large meanders develop and form "cold filaments" of recently upwelled water that can extend more than 200 km offshore. Filaments are observed most commonly near coastal promontories such as Cape Mendocino, Point Arena, Point Reyes, and Point Sur. The Point Arena filament was observed in six different surveys during July and August 1988 (Huyer et al. 1991). Offshore velocities along the northern side of the filament approached 100 cm/sec (2 knots), which is far greater than the large scale mean flow toward the south.

During October through November and February through March, nearshore flows over the shelf and upper slope south of Cape Mendocino move northward against weak, northerly, prevailing winds. At the same time, the southward flow of the California Current weakens and moves offshore.

Winter is a period of storms that can produce large, storm-generated surface waves and strong fluctuating currents that can last for 2 to 10 days.

During any particular month, the flow pattern may differ significantly from the seasonal mean conditions. Much of this variability is attributable to small-scale features (e.g., eddies and filaments) with short time scales, but there is also interannual variability on large spatial and temporal scales (Chelton et al. 1987). For example, in some years the coastal southerly (poleward) winds do not weaken in the spring and summer but actually increase. This may weaken upwelling and cause warmer than usual, nutrient-poor water to predominate. These "El Nino" conditions result in a dramatic decline in ocean food production and reduced survival and reproductive success of many marine organisms. The distribution of many mobile marine species changes substantially in such years as organisms search for alternative food resources. Evidence from the tropical Pacific indicates that 1991 to 1992 was an El Nino year.

Waves

The wave climate is seasonally variable for the coastal area off San Francisco within the Gulf of the Farallones. Wave heights are usually greater during the late fall, winter, and spring due to the presence of storms and generally stronger, sustained winds. In contrast, wave heights are generally lower during the summer and early fall due to decreasing and variable winds. Because wave-induced currents generated during winter storms can reach depths of 100 m or more, fine grained sediments on the bottom at these depths on the continental shelf can be resuspended (Noble et al. 1992). The mean currents carry suspended materials mainly along isobaths (bottom contours of the same depth) until conditions calm and the particles settle out again.

Tides

Mixed semidiurnal tides occur on the west coast in the vicinity of San Francisco. Diurnal tides are strongest on the continental shelf in the Gulf of the Farallones (Noble and Gelfenbaum 1990), with tidal amplitudes between 6 and 9 cm/sec. Lunar tidal currents are strongest on the slope adjacent to the Gulf of the Farallones, with amplitudes from 2.3 to 4.4 cm/sec (Noble and Kinoshita 1992). Semidiurnal and diurnal tides together account for 35 to 60 percent of the total variability in the currents on the shelf, and from 15 to 33 percent of the variability on the slope. These tidal currents can affect the resuspension of material deposited on the seabed and dispersion of material suspended in the water column. However, studies by EPA indicate that the ocean bottom in the vicinity of the SF-DODS (and generally across the region at depths greater than 600 to 800 meters) is depositional (see section 4.5.2.3 below).

4.5.2.2 Water Quality

Water quality characteristics relevant to dredged material disposal include temperature, salinity, turbidity, dissolved oxygen, and contaminant concentrations. Each of these is discussed briefly below. More detailed information is provided in the SF-DODS FEIS (USEPA 1993a).

Temperature and Salinity

Recent hydrographic and current measurements indicate that the outer shelf and slope regions of the Gulf of the Farallones are a dynamic area (Ramp et al. 1992). Surface waters show a great deal of variability in temperature-salinity (T-S) properties. For example, during recent EPA-sponsored surveys (Ramp et al. 1992), near-surface waters represented a mixture of three primary water types: (1) recently upwelled water from a source primarily to the north of Point Reyes; (2) offshore water from the large-scale California Current system; and (3) outflow from San Francisco Bay. The characteristics and importance of each water type in the Gulf vary seasonally and on shorter (i.e., event-related) time scales.

Water discharged from San Francisco Bay into the Gulf of the Farallones has a higher temperature and lower salinity, and therefore lower density, than water in the Gulf. The long-term average salinity at Southeast Farallon Island is 33.4 parts per thousand (ppt), whereas, at Fort Point on the south side of the Golden Gate, the average salinity is 29.9 ppt (Peterson et al. 1989). Historically, salinities at both locations are lowest during winter and spring, when the Delta outflow is highest. Due to its lower density than ambient waters, the outflow from San Francisco Bay is confined to the surface layer in the Gulf of the Farallones.

Temperature and salinity parameters collectively determine the density of any particular water mass. A pycnocline (rapid change in density with changing depth) results when two water masses of different densities are superimposed in the water column. In the vicinity of SF-DODS, water column stratification due to a pycnocline may occur seasonally at approximately 100 meters. Theoretically, horizontal dispersion of neutrally buoyant, fine-grained material would be expected to occur in a stratified water column. This kind of dispersion can spread particulate matter farther that would occur if the same material were dumped into an unstratified body of water. However, other factors may be more significant in determining the extent of overall dispersion, including bargeload volume and density, the resulting momentum of the convective descent phase of a disposal event (Figure 4.5-2), and sinking rate of aggregates. Recent field verification studies of actual disposal events (PRC 1995) indicate that excessive water column dispersion does not occur at SF-DODS. Particulate levels rapidly return to background values, and water column plumes dissipate, entirely within the ocean disposal site boundaries.

Turbidity

Water turbidity or light transmittance properties on the continental shelf near the Golden Gate are affected by seasonal and tidal flows of turbid waters from San Francisco Bay. The location and aerial extent of the outflow plume in the nearshore surface waters off San Francisco change seasonally. During recent hydrographic surveys of the region (Ramp et al. 1992), outflow from San Francisco Bay was observed to the north of the Golden Gate during August, directly off the Golden Gate during November, and to the south and farther offshore during February 1991. The distribution of the outflow plume may have been influenced by prevailing nearshore wind stress. None of the observed plumes extended very far offshore, likely due to limited freshwater runoff associated with drought conditions. However, previous studies noted a plume of turbid water extending approximately 46 km offshore during peak spring flows from the Bay (Carlson and McCulloch 1974). The relative spatial extent of the turbid surface plume is reduced in summer when flows from the Bay are minimal. Some of the turbidity in continental shelf areas may be related to resuspension of sediments near the bottom and inorganic suspended particles or phytoplankton within the near-surface mixed layer (Nybakken et al. 1984).

In the vicinity of SF-DODS, the background turbidity values are variable, but mean values range from 1 to 3 mg/l. Field verification studies during actual disposal events have indicated that plumes dissipate rapidly to background levels within the ocean disposal site boundaries (PRC 1995); thus wide area effects, including turbidity increases in the national marine sanctuaries, are not expected.

Dissolved Oxygen

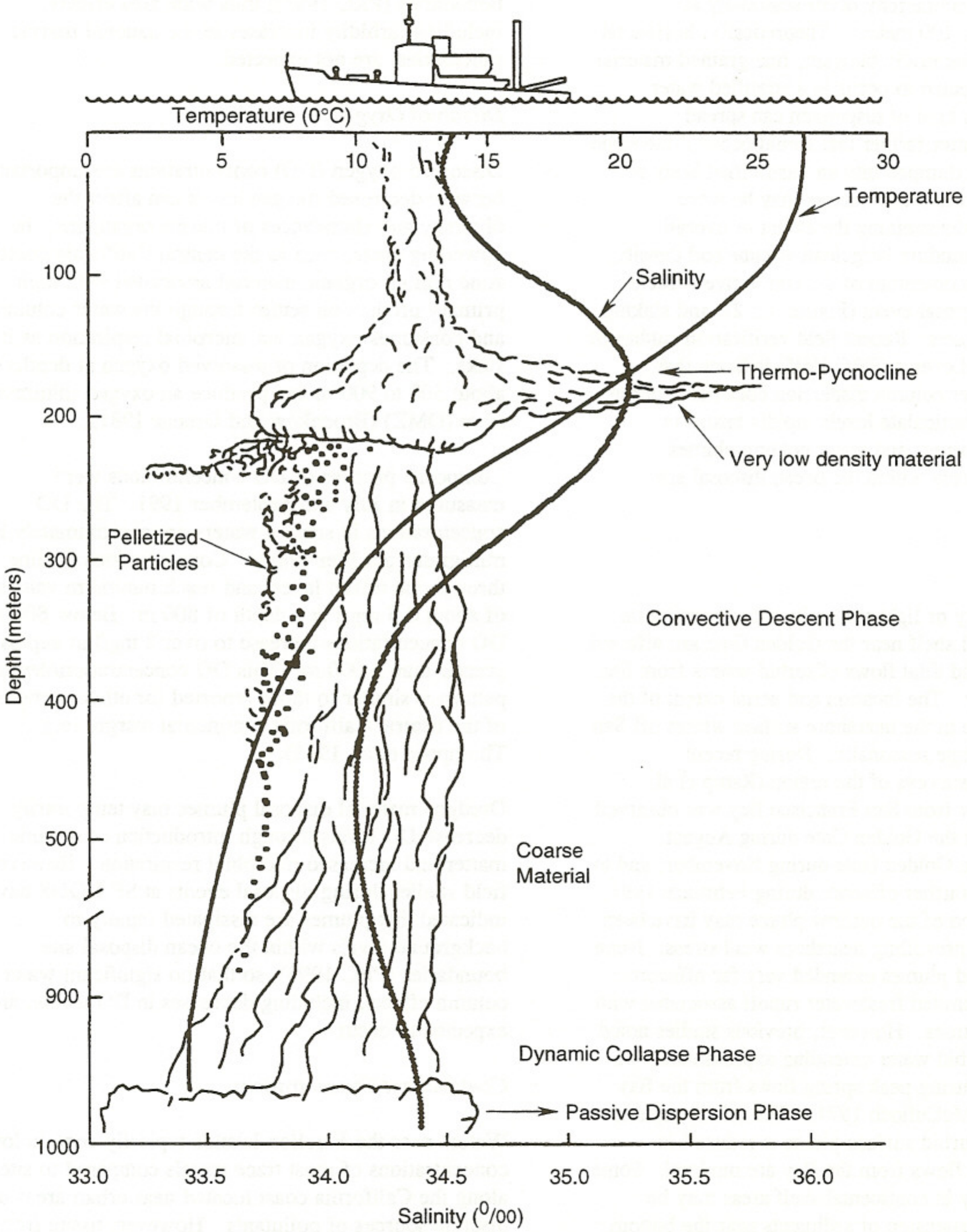
Dissolved oxygen (DO) concentrations are important because depressed oxygen levels can affect the diversity and abundances of marine organisms. In upwelling areas, such as the central California coastal zone region, organic material associated with high primary production settles through the water column and consumes oxygen via microbial respiration as it sinks. The depletion of dissolved oxygen at depths of about 500 to 900 m can produce an oxygen minimum zone (OMZ) (Broenkow and Greene 1981).

Composite profiles of DO concentrations were measured in July and September 1991. The DO concentrations in surface waters are approximately 8 milligrams per liter (mg/l). Concentrations decline through the mixed layer, and reach minimum values of about 0.5 mg/l at a depth of 800 m. Below 800 m, DO concentrations increase to over 3 mg/l at depths greater than 2,000 m. This DO concentration/depth pattern is similar to those reported for other portions of the central California continental margin (e.g., Thompson et al. 1985).

Dredged material disposal plumes may temporarily decrease DO levels through introduction of organic matter and increased microbial respiration. However, field studies during disposal events at SF-DODS have indicated that plumes are dissipated rapidly to background levels within the ocean disposal site boundaries (PRC 1995), so that no significant water column effects, including decreases in DO levels, are expected to occur.

Contaminant Concentrations

Waters near the Farallon Islands typically contain low concentrations of most trace metals compared to sites along the California coast located near urban areas or discrete sources of pollutants. However, tissue from mussels from the Farallon Islands historically contained high lead concentrations relative to concentrations in mussels from several central California locations. The source of the lead is unknown; however, the location of the Farallon Islands upwind from potential combustion sources would minimize atmospheric deposition sources (Farrington et al. 1983; Goldberg and Martin 1983).



Note: This figure of dredged material disposal is adapted to a two-layered deepwater system (1000m) with a strong thermo-pycnocline.

Source: Pequegnat et al. (1978)

Figure 4.5-2. Transport Processes During Open-Water Disposal

Elevated concentrations of some elements (including cadmium in mussels at the Farallon Islands) probably are related to upwelling of subsurface waters that are relatively enriched with these elements (Farrington et al. 1983; Bruland et al. 1991).

Nybakken et al. (1984) reported very low concentrations of petroleum hydrocarbons (140 to 280 ng/liter) in outer continental shelf waters. Similarly, deLappe et al. (1980) reported that the polynuclear aromatic hydrocarbons (PAHs) phenanthrene and pyrene in waters near the Farallon Islands were below analytical detection limits. Organochlorine compounds were not detectable in seawater collected at the 100-fathom site (IEC 1982). However, Nybakken et al. (1984) measured concentrations of total (dissolved and particulate) polychlorinated biphenyls (PCBs) of 24 to 105 ng/liter, dichloro-diphenyldichloroethylene (DDE) of 4.6 to 27 nanograms per liter (ng/liter), and trace amounts (less than 500 ng/liter) of chlordane, hexachlorocyclohexane, dieldrin, and toxaphene in waters over the continental shelf and shelf edge.

Dredged material disposal plumes may temporarily influence dissolved contaminant concentrations. Pre-disposal testing requirements (e.g., "Green Book" testing, USEPA and USACE 1991) address potential water column toxicity in a conservative manner (e.g., constant exposure levels for 48 to 96 hours to sensitive larval marine organisms); compliance with testing guidelines is expected to minimize the potential for water column contaminant effects (see discussion of contaminant exposure pathways in aquatic environments, section 3.2.4.1). In addition, exposure levels are not constant in the water column following disposal, and do not last for 48 to 96 hours. Field studies during disposal events at SF-DODS have indicated that plumes are dissipated rapidly to background levels, generally in less than an hour, within the ocean disposal site boundaries (PRC 1995), so that no significant water column effects, including effects from exposure to elevated contaminant levels, are expected to occur.

4.5.2.3 Offshore Geology

The SF-DODS FEIS (USEPA 1993a) documented the geological conditions at a number of potential ocean disposal sites. The discussion in the FEIS was based, in part, on studies conducted for EPA by the U.S. Geological Survey (USGS) in 1990. The USGS's studies (Karl 1992) included geological, geophysical, and geotechnical surveys across 3,400 km^2 of the region ranging in depths from 200 to 3,200 m. Regional geologic data were used to evaluate bottom stability and sediment transport, as well as other physical and benthic processes, and to identify areas of sediment erosion, bypass, and accumulation.

The SF-DODS is located in the physiographic province called the Farallones Escarpment. Within the province are two geomorphic areas: a northern segment where the escarpment is about 35 kilometers (km) wide with a slope of 6 degrees or more, and a southern segment where the width of the escarpment is about 75 km wide with a slope of about 2 degrees. The approximate boundary between the northern and southern geomorphic areas is 37"30'N. The SF-DODS is within the northern segment.

The relatively narrow northern segment of the escarpment has the more rugged topographic relief. It is transected by numerous gullies and canyons that are oriented roughly perpendicular to the regional trend (generally northwest-to-southeast) of the Farallones Escarpment. A canyon within the SF-DODS represents one of these slope features. Between the gullies and canyons are steep inter-canyon ridges that consist of barren rock outcrops of consolidated or hardened strata and crystalline basalt (Chin et al. 1992). Within the gullies and canyons unconsolidated muds have accumulated to thicknesses up to 5 m.

Although the northern area has rugged topography and relatively steep slopes, no unequivocal evidence of mass sediment movement in the vicinity of SF-DODS has been found (SAIC 1992a). All evidence of slumping is limited to steep slopes and walls of submarine canyons. The inter-canyon ridges are subject to erosion. However, SF-DODS is within a low kinetic energy (depositional) area within a trough. This depositional area is deeper (between 2,200 and 3,000 m) than other depositional sites found in the alternative study areas evaluated in EPA's FEIS. The depositional nature of SF-DODS is in contrast to the "erosional" characteristics of the existing disposal sites within San Francisco Bay, and has important implications for disposal site management (see section 3.2.4).

Sediments deposited on the continental slope from natural processes originate from a variety of sources including material carried from the San Francisco Bay and nearby rivers, erosion of the coastline, and erosion and bottom transport of bottom material on the continental shelf and continental slope. In general, the grain size of sediments deposited on the bottom of the ocean decreases with increasing depth. SAIC (1992a) identified that substrate composition is predominantly sand on the continental shelf at depths less than 600 m to 800 m, where waves and bottom currents can be strong enough to scour the bottom, preferentially removing finer-grained particles. Below this transition depth, scouring effects are generally reduced and finer-grained sediments (sandy-mud, and finer) tend to predominate. The natural substrate in the SF-DODS is composed primarily of fine-grained silts and clay, typical of the depositional areas in the region. No hard-bottom features occur within the site, and it does not contain any unique or unusual geologic features. Analysis of the sediments collected in core samples in the SF-DODS reveal only background levels or low concentrations of trace metals and organic compounds.

4.5.2.4 Physical Environment Summary

In summary, a variety of physical conditions at the SF-DODS indicate it is an appropriate location for ocean disposal of dredged material. Currents in the vicinity of the SF-DODS are generally slow, which aids in minimizing the spread of water column plumes during and immediately following disposal events. Since the currents predominantly flow away from the adjacent national marine sanctuaries and important biological resources, the potential for water column effects is further minimized. In terms of benthic impacts, the site has natural topographic features that help to physically contain the spread on the bottom of any dredged material disposed there. It is within an area that is depositional in nature, which also helps to retain deposited dredged material within the site boundaries. The depositional character of the SF-DODS is an important factor in terms of site management: depositional sites facilitate monitoring of site performance, ensuring that predictions about the degree of benthic impact can be verified. This is in contrast to erosional sites, such as those within San Francisco Bay, for which the ultimate fate (and therefore impacts) of dredged material disposal cannot be determined with accuracy. Certain management actions, such as capping of contaminated sediments, are also more feasible at depositional sites. All of these physical characteristics — which minimize the potential for organism exposure to, or impact from, disposed dredged material — were important factors in the identification of the SF-DODS as the environmentally preferred ocean disposal location, and in EPA's decision to select this site for formal designation in 1994.

4.5.3 Biological Resources

The following discussion of the key biological resources and processes in the vicinity of the SF-DODS is summarized from the *Final Environmental Impact Statement (FEIS) for Designation of a Deep Water Ocean Dredged Material Disposal Site off San Francisco, California* (USEPA 1993a). Supporting reference material is extensively cited in that document.

Biological resources in the SF-DODS can be separated into three basic communities when addressing potential environmental impacts. These include the pelagic community, the terrestrial-based marine community, and the benthic community. Each community contains numerous species with different life history strategies, and each community is interlinked with the others in the overall food web. Although special status species are included in the following discussion, they are described in more detail in section 4.5.3.5.

4.5.3.1 Pelagic Community

The biological community in the pelagic or open water area of the SF-DODS changes with increasing depth. Different assemblages of species occur in the epipelagic (surface to 200 m deep), mesopelagic (200 m to 1,000 m deep), and bathypelagic (below 1,000 m deep) zones.

Phytoplankton and Zooplankton

Most photosynthesizing algae occur in the epipelagic zone. In the open ocean, phytoplankton (single-celled algae) convert nutrients dissolved in the water column into plant material when sufficient light is present. During the upwelling season in March through August, phytoplankton abundance increases dramatically in the ocean in response to higher nutrient levels. Nutrient input from the San Francisco Bay also leads to high primary production in the area. The phytoplankton community is comprised primarily of diatoms, silicoflagellates, coccolithophores (Chrysophyta) and dinoflagellates.

Zooplankton are an extremely important component of the food web in the epipelagic zone. Three groups of animals comprise the zooplankton community, including holoplankton that remain planktonic throughout their life, meroplankton that are the larval stages of benthic invertebrates, and icthyoplankton that are the larval stages of fish.

Holoplankton are the primary consumers of phytoplankton in the open ocean and serve as the primary conduit for energy transfer between the plant and animal assemblages. Holoplankton are consumed directly by other holoplankton species; larval stages of benthic invertebrates; larval, juvenile and adult fish; sea birds and marine mammals. Holoplankton also indirectly support almost all pelagic species in the ocean by providing energy at the bottom of the food web that ultimately filters through every organisms' prey species. The most important holoplankton in the SF-DODS are copepods, euphausiids, thalacians (salps), chaetognaths, and pelagic molluscs.

Limited information is available on meroplankton within the study area. Most of the information is derived from incidental catches in surveys targeting other organisms or from mid-water trawls (USEPA 1993a). The meroplankton most commonly found in offshore areas include squid, octopuses, and the larval stages of several species of crabs, including Dungeness crab. However, the overall abundance of meroplankton in offshore areas is considerably lower than in nearshore areas.

Ichthyoplankton (larval fishes) may be an important component of zooplankton during certain times of the year. Over 1,000 species are known to occur in the California current systems. The abundance of larval fish changes substantially on a seasonal and annual basis. However, in general, high densities of larval fish are found in shallower water than occurs at the SF-DODS. The SF-DODS does not appear to be a unique area where larval fish congregate or a critical area where individuals of one particular species develop.

Fish

Zooplankton in the epipelagic zone attract pelagic fish species that either feed directly on the zooplankton or on the other plankton-feeding fish. Some of the planktivorous fish that may occur in the vicinity of the SF-DODS include Pacific herring, Northern anchovy, Pacific sardine, and juvenile rockfish. Predatory fish moving into the area to feed on schools of planktivorous fish include tuna, mackerel, and salmon.

Many mesopelagic fish commonly migrate into the upper surface waters at night to feed on plankton and planktivorous fish. Members of the family of deep-sea smelt, lanternfish, and viperfishes make these diurnal migrations. These fish species, in addition to hatchetfish, also occur in the upper regions of the bathypelagic zone.

Marine Mammals (Cetaceans)

Seventeen species of cetaceans (whales, dolphins, and porpoises) are frequently observed near the SF-DODS in the Gulf of the Farallones. In general, the highest densities of cetaceans occur in the continental slope waters at depths between 200 and 2,000 m, whereas the depth at the SF-DODS ranges from 2,500 m to 3,000 m. The highest densities of cetaceans in the vicinity of SF-DODS occur from March through May. This time period corresponds to the period of upwelling in the overall region when high phytoplankton and zooplankton production attracts many fish.

The seven species of whales that have been observed in the vicinity of SF-DODS are all classified as either migrants or seasonal visitors. Whales that only migrate through the area and rarely stop to feed (migrants) include the finback, sperm, sei, and right whales. Whales that also migrate through the area but commonly feed opportunistically on pelagic and benthic organisms (seasonal visitors) include the gray, humpback, and blue whales. All these whales pass near the SF-DODS during their northern migration to the Bering Sea in the spring and during their southern migration to lagoons in Baja California in the late fall. Gray, humpback, and blue whales may also be found feeding in the area in the late summer during migration respites.

Five species of toothed cetaceans are commonly observed in the vicinity of the SF-DODS, including (listed in order of decreasing abundance) Pacific white-sided dolphin, northern right whale dolphin, Risso's dolphin, Dall's porpoise, and harbor porpoise. The common dolphin may also occur in the area although they are predominantly found on the continental shelf miles inshore of the SF-DODS. Important food organisms for dolphins and porpoises in the area include squid, Northern anchovy, juvenile rockfish, and mesopelagic fish such as lanternfish. Other whales that have been observed in the Gulf of the Farallones but not documented in the vicinity of SF-DODS include the beaked whale, killer whale, minke whale, and pilot whale.

4.5.3.2 Terrestrial-Based Marine Community

An important component of biological resources in the SF-DODS and in adjacent area are marine mammals and birds whose activities are centered around the Farallon Islands. The Farallon Islands are commonly used for nesting or resting habitat. Marine mammals and birds from the Farallon Islands sometimes venture into the vicinity of SF-DODS during foraging activities. As noted previously, the Farallon Islands contain "the most important marine bird breeding sites on the west coast of the continental United States" and "one of the most important pinniped (sea lions and seals) haulout grounds in California" (USEPA 1993a).

Marine Birds

Marine birds are those species that spend at least one-half of the year over water and derive the majority of their food from the ocean. The Farallon Islands support the world's largest breeding colony of ashy storm-petrels (85 percent of the world population), Brandt's cormorants (10 percent of the world population), and western gulls (50 percent of the world population). Two special status species (peregrine falcon and brown pelican) also are found associated with the Farallon Islands (see section 4.5.3.5).

Although more than 122 species have been observed in the region of the Farallon Islands, only 63 marine birds are considered to regularly occur in the region. Of these 63 species, 14 breed on the Farallon Islands, 37 are seasonal visitors, and 12 are passage migrants. A comprehensive list of these species can be found in USEPA (1993a).

USEPA (1993a) focused attention on 10 species of marine birds to characterize overall distribution, habitat use, and foraging behaviors in the vicinity of the SF-DODS and the Farallon Islands. These species included the ashy storm-petrel, Brandt's cormorant, western gull, common murre, pigeon guillemot, sooty shearwater, Cassin's auklet, rhinoceros auklet, pink-footed shearwater, and tufted puffin. In general, the distribution of marine birds is influenced by the abundance of pelagic juvenile rockfish (the preferred prey species) in the Gulf of the Farallones, especially during the late spring and summer. Pelagic juvenile rockfish abundance is high in years when strong upwelling occurs and low in years when upwelling is weak, such as during El Nino.

In years when juvenile rockfish are highly abundant, most foraging activity of marine birds is concentrated around breeding and resting sites on the Farallon Islands, far from the SF-DODS. In years when juvenile rockfish are less abundant, marine birds are more widely scattered throughout the gulf. Although the birds are found throughout the GOFNMS, areas along the continental shelf receive heavier use because of greater food production. The offshore area including the SF-DODS would also receive relatively high use during this time, despite relatively low prey abundance, because of its close proximity to the Farallon Islands and favorable location relative to prevailing winds from the north. Many prey items are taken when juvenile rockfish are scarce, including squid, zooplankton, Northern anchovy, and smelt.

Marine Mammals (Pinnipeds)

The Farallon Islands are important haulout areas for many species of pinnipeds (sea lions and seals). These species have rarely been observed in the vicinity of the SF-DODS. Sea lions and seals forage primarily along the continental shelf in the summer and fall and on the upper continental slope in the winter and spring. The California sea lion is the most abundant pinniped using the Farallon Islands, peaking in abundance in May and June and September and October. Northern elephant seals peak in abundance in the spring on the islands and have established breeding colonies on the Southeast Farallon Islands. The federally threatened northern sea lion usually is found in relatively shallow water close to shore, although a rookery does exist on the Southeast Farallon Islands. Although, the northern fur seal may be found near the Farallon Islands year-round, it is considered to be primarily a winter-spring pelagic visitor to the region.

The pinnipeds feed on a wide variety of food organisms including crabs, squid, herring, mackerel, octopus, anchovies, adult rockfish, and smelts. Although most of these organisms may be found in the vicinity of the SF-DODS, they are considerably more abundant on the continental shelf. The pinnipeds generally forage more extensively along the shelf due to greater food abundance and greater protection from predators compared to the open ocean.

4.5.3.3 Benthic Community

The benthic community in the SF-DODS is composed of invertebrates that burrow in the substrate (benthic infauna), invertebrates that live on the surface of the substrate (epifauna) and fish that are closely associated with the substrate (demersal fish). The benthic community is discussed separated from the pelagic community because the potential impacts of dredged material disposal are different for each community. The benthic community in the SF-DODS is found in depths ranging between 2,500 and 3,000 m, where environmental conditions are relatively harsh due to low oxygen, low food abundance, no light, high pressure, and low temperature. As a result, the number of species and overall abundance of organisms in this area is relatively low compared to shallower areas on the continental shelf.

The benthic infauna community in the vicinity of the SF-DODS contains over 385 species. Most of the species present are polychaetes (48 percent of total species) followed by crustaceans (32 percent) and molluscs (8 percent). The remaining 12 percent of the species are found in a wide variety of taxa. The benthic infauna at the SF-DODS is typical of most deep-sea infaunal communities. No unique species or habitat was found during extensive sampling in the SF-DODS.

Similar to the infauna community, the demersal epibenthic community is characterized by a low number of taxa (low diversity) and low densities. Surveys summarized in the FEIS prepared by USEPA (1993a) identified 95 taxa of epibenthic invertebrates in the SF-DODS. The surveys did collect at least five species that were "previously unknown to science" (USEPA 1993a). The epibenthic community is predominately composed of sea cucumbers, brittlestars, seastars (*echinoderms*), and sea pens (*cnidarians*).

The demersal fish community in the SF-DODS is also characterized by relatively low diversity and densities of organisms. A total of 15 species of demersal fish have been collected in the region. The most common species are rattails, thornyheads, finescale codling, and eelpouts.

4.5.3.4 Commercially and Recreationally Important Species

The SF-DODS lies within one of the least productive commercial and recreational fishery resource areas, compared to other areas on the continental shelf and upper continental slope. Common commercially or recreationally important fishes potentially occurring in the vicinity of the SF-DODS include the following: adult Pacific herring, adult salmon, adult tuna, adult mackerel, juvenile Pacific hake, juvenile pelagic rockfish (shortbelly rockfish, boccacio, yellowtail rockfish), juvenile flatfishes (rex sole and Dover sole), and adult rattails. The commercially or recreationally important invertebrates collected within the Gulf of the Farallones (including Dungeness crab, market squid, and several species of shrimp) rarely occur in the deep continental slope waters near the SF-DODS. In general, fishery resources on the continental shelf are of greater economic value than those in deeper waters.

4.5.3.5 Special Status Species

The USEPA (1993a) identified eight threatened or endangered species that may occur in the general vicinity of the SF-DODS. These protected or listed species include four cetaceans (humpback whale, blue whale, finback whale, and sperm whale), one pinniped (northern sea lion), two birds (peregrine falcon and California brown pelican), and one fish (winter-run Chinook salmon). The Endangered Species Act prohibits the take of any listed species, generally defined as prohibiting any harassment, harm, pursuit, hunting, shooting, wounding, killing, trapping, capture, collection, or attempts at such conduct. In addition to the listed species identified above, the Marine Mammal Protection Act of 1972 established a moratorium on the killing or harassment of any marine mammals. The following briefly summarizes the life history of the eight listed species and their occurrence in the SF-DODS.

Humpback Whale

Humpback whale populations have declined from 150,000 individuals prior to intensive hunting in the late 1800s to approximately 25,000 individuals today (Thelander et al. 1994). Currently, the humpback whale is listed as federally endangered. In the Gulf of the Farallones, humpback whales are more abundant from March through January, with greatest concentrations near the Farallon Islands from mid-August through October. Local populations of humpback whales are estimated at 150 to 200 individuals during the late summer. These whales are highly migratory, spending the spring and early summer feeding off the coast of Alaska and the winter breeding in tropical waters off Hawaii and Mexico.

Humpback whales are commonly observed in continental shelf waters considerably inshore of the SF-DODS. The National Marine Fisheries Service (NMFS) in 1991 designated critical areas of nearshore habitat along the California coasts for special protection in their recovery plan for the humpback whale. The primary food organisms taken by these whales off the California coast are baitfish, krill (euphausiids), and pelagic crabs. These food organisms are generally more abundant in continental shelf water. The USEPA (1993a) did not document any sightings of humpback whales in the SF-DODS in their review of surveys conducted between 1985 and 1991.

Blue Whale

The worldwide population of blue whales declined due to intensive hunting from approximately 200,000 in the early 1900s to 12,000 today. The blue whale is currently listed as federally endangered. The blue whale population along the entire California coast during the summer and autumn has been estimated to be around 2,000. Studies conducted in the Gulf of the Farallones identified 179 blue whales from 1986 through 1988. Most of these whales were observed in the summer and early fall feeding on krill (euphausiids) along the continental shelf break. Surveys conducted in the area in 1990 and 1991 failed to detect any blue whales within the SF-DODS. All sightings of blue whales during these surveys were more than 10 nmi from the SF-DODS.

Finback Whale

The finback whale population has decreased considerably, from around 26,000 individuals historically to less than 11,000 today. This whale, which is federally endangered, is considered to be only a migrant within the Gulf of the Farallones, rarely stopping to feed. In fact, the whale is thought to fast through the entire winter (Thelander et al. 1994). They pass through the Gulf of the Farallones twice a year: during their northern migration to the Bering Sea in the spring/early summer and during their southern migration to tropical waters in the fall/early winter.

The finback whale has primarily been sighted over continental shelf and upper slope water during their migrations. No finback whales have been observed near the SF-DODS. During the spring and summer, these whales feed on a variety of prey organisms off the continental shelf including krill, squid, pollack, anchovies, and other schooling fish.

Sperm Whale

Although listed as federally endangered, the sperm whale has recovered to population levels just slightly below historical estimates (930,000 today compared to 1,260,000 historically). These whales supported most of the whaling activities in the world from the 1770s through the early 1900s. Unlike the endangered whales discussed above, the sperm whale prefers the deep water off the continental slope. This whale has the ability to dive to depths of 3,000 m compared to only 230 m for most endangered whales. In studies conducted in the early 1980s, 69 percent of all sperm whale sightings were in water greater than 1,700 m deep.

The sperm whale is relatively common in the Gulf of the Farallones, with peak abundance occurring in mid-May and mid-September. The whale migrates past the area twice a year during its movement between northern subarctic water and southern tropical waters. The whale rarely stops to feed in the Gulf of the Farallones. However, the whales will feed opportunistically on giant squid, octopus, sharks, longnose skates, lingcod, hake and juvenile rockfish, and other fish species. Many of these prey species are taken in extremely deep water in total darkness. Four individuals were sighted in the SF-DODS in 1983, and their occurrence in the SF-DODS is not surprising due to their preference for deep-water habitat.

Northern Sea Lion

The California population of federally threatened Northern (Steller) sea lion has declined from 6,000 individuals in 1960 to less than 2,000 in 1989. Reasons for their decline included mortality from commercial fishing, disease outbreaks, and water pollution; changes in ocean currents affecting migration rates and food production; and reductions in prey populations due to overfishing. The California breeding population represents approximately three percent of the worldwide population. Adult males from California migrate to the coasts of Alaska and British Columbia when not breeding (August to April).

Most Northern sea lions in California are found in four shallow water areas within 45 km of the coast: (1) Cape Mendocino to the Klamath River; (2) Cordell Bank; (3) just north of Point Arena; and (4) the continental slope between the Farallon Islands south to AZo Nuevo Island. The largest rookery in California (>1,000 animals) is established on AZo Nuevo Island. A smaller rookery (200 animals) also exists on Southeast Farallon Island, within 25 nmi of the SF-DODS. Only one northern sea lion has been observed near the SF-DODS in recent years. Northern sea lions in California typically feed at night in shallow continental shelf waters (< 180 m in depth) on squid, octopus, and fish such as rockfish, smelt, and hake.

Peregrine Falcon

The peregrine falcon is presently listed as both federally and state endangered. The USFWS is considering reclassifying the bird to federally threatened due to the recovery of breeding populations (Thelander et al. 1994). Breeding pairs are territorial and remain near the nesting site throughout the year. Non-breeding adults and immature birds from California often migrate long distances and may winter from central Oregon to northern Mexico. Peregrine falcons historically maintained breeding sites on the Farallon Islands.

Currently, the falcons are relatively rare in the region with no known nesting sites. Approximately five to eight falcons have been observed wintering on the islands in recent years. These birds use the ocean cliffs for perching. The falcons feed almost exclusively near the islands on other birds species.

California Brown Pelican

The California brown pelican is currently listed as both federally and state endangered. Breeding colonies of brown pelican in California are confined to the Channel Islands off the coast of southern California. However, the majority of pelicans migrate south to the Gulf of California or to the Pacific Ocean off Baja California to breed. After the nesting season, the birds migrate northward to feed on schooling baitfish along the coastline from California to British Columbia. The birds are most common in California in late July to October. Large numbers of pelican roost on the Farallon Islands at night during this time. During the day, they feed on schooling fish along the continental shelf and upper continental slope in water generally less than 180 m deep. The most common fish eaten are Northern anchovy, Pacific sardine, and Pacific mackerel.

Winter-run Chinook Salmon

The population of winter-run Chinook salmon has dramatically decreased in recent years. Spawning populations have dropped from between 60,000 and 120,000 fish in the 1960s to a record low of 191 in 1991 (CDFG 1992). Winter-run historically spawned in the upper Sacramento River and its tributaries, but construction of Shasta Dam in 1943 blocked access to these spawning areas (Moyle et al. 1989). Winter-run spawning is now largely restricted to the Sacramento River between the Red Bluff Diversion Dam (RBDD) and Keswick Dam.

Other Protected Species

The USEPA (1993a) has identified several other protected species that may occur in the vicinity of the SF-DODS, but their presence would be very unlikely and considered atypical. These species include the sei and right whales (federal-endangered); Guadalupe fur seal (federal and state-threatened); southern sea otter (federal-endangered); short-tailed albatross (federal-endangered); marbled murrelet (federal-threatened, state-endangered); and leatherback turtles (federal-endangered).

4.5.3.6 Biological Resources Summary

In summary, the SF-DODS is removed from important commercial or recreational fishery areas, and from important or unique habitats or other amenity areas. Compared to some alternative sites studied, the SF-DODS area receives somewhat higher use by marine mammals and seabirds, and some mid-water organisms including juvenile rockfish are seasonally more abundant. However, impacts to any of these resources from dredged material disposal are expected to be insignificant. The lack of important commercial or recreational fishery areas, and the lack of important or unique habitats or other amenity areas, were important factors in the identification of the SF-DODS as the environmentally preferred ocean disposal location, and in EPA's decision to select this site for formal designation in 1994.

4.5.4 Pollutants and Historic Impacts

Historically the SF-DODS and adjacent areas within the Gulf of the Farallones have been used for disposal of dredged materials, chemical and conventional munitions, and low-level radioactive waste. The B1B ocean dredged material disposal site, located approximately 20 nautical miles offshore of Half Moon Bay, was used between May 12 through 16, 1988 for disposal of 18,000 cubic yards (six hopper bargeloads) of sediments from the Port of Oakland Harbor Deepening Project. This site was selected as part of a project-specific site designation for this project only (USACE 1988). Disposal operations at this site ceased as a result of a lawsuit and a State Court injunction (USACE 1989). This site was eliminated from consideration as a permanent ocean dredged material disposal site during a subsequent site designation process implemented by the EPA. A major factor for elimination of this site was its location within the boundaries of the Monterey Bay National Marine Sanctuary. In 1993 and 1994, dredged material from the Naval Air Station (NAS) Alameda and Naval Supply Center (NSC) Oakland was permitted for discharge at a project-specific Navy site contained entirely within the SF-DODS. The SF-DODS is, in turn, located within the overall boundaries of the historical Chemical Munitions Dumping Area (CMDA). The CMDA had been used to dispose of both chemical and conventional munitions in the late 1950s and 1960s. The SF-DODS is also located near a broad area where deep ocean disposal of radioactive waste occurred between 1946 and 1965. The pollutants and impacts associated with these disposal activities are described below.

4.5.4.1 Dredged Material Disposal

Approximately 1.2 mcy of dredged material from channel deepening at the NAS Alameda and the Naval Field and Industrial Supply Center Oakland (formerly called the NSC Oakland) was permitted for disposal in 1993 at a project-specific site within the later permanently-designated SF-DODS (a total of approximately 940,000 cy was eventually disposed under this permit). The project-specific disposal site was designated under Section 103 of the Marine Protection, Research, and Sanctuaries Act (MPRSA) (see section 4.8), and only allowed disposal of dredged materials from that project that were determined by EPA and the COE to be suitable for ocean disposal. The final supplemental EIS for the Navy project (U.S. Navy 1993) selected the area as the environmentally preferred location for many of the same reasons later noted by EPA in its permanent designation of the SF-DODS (USEPA 1994c).

In contrast to EPA's later site designation action, the Navy's selection of this area as preferred was based only on modeling of dredged material disposal at the site (e.g., water column plume dispersion and benthic deposition ["footprint"] modeling). Site-specific disposal monitoring results were not yet available, because no dredged material had ever been disposed there (nor at any ocean disposal site in similar depths). To confirm whether modeled disposal characteristics were realistic, and whether changes to disposal methods or locations within the disposal site might be necessary, the COE ocean disposal (MPRSA Section 103) permit for the Navy's project required extensive monitoring of actual disposal events after approximately the first half of the permitted project volume had been disposed. This "mid-point" monitoring occurred after approximately 750,000 cy of the permitted 1.2 mcy had been disposed. As mentioned in the preceding sections, this monitoring confirmed that the site performed at least as well as predicted by the models and that, in some aspects, it exceeded expectations based on the modeling. For example, much less dredged material was found to remain in the water column following each disposal event than was predicted based on modeling. Similarly, the percentage of dredged material that reached the seafloor at the disposal site (i.e., that did not disperse as a water column plume) was estimated through physical monitoring to be between 60 and 83 percent; this was greater than was previously predicted based on modeling.

4.5.4.2 Chemical and Conventional Munitions Waste

The U.S. Army discharged both chemical and conventional munitions at offshore sites beginning in the late 1950s. From 1958 through 1969, the Army and Navy occupied several ocean sites off San Francisco for the purpose of munitions disposal. One of the sites used for waste munitions was within the SF-DODS. Munitions waste discharges were made at this site through 1968 and 1969, usually by towing barges of one-ton containers and unloading the containers overboard. During this time, a program was also initiated that used obsolete World War II cargo ships to dispose of large amounts of old munitions at offshore sites. The ships were loaded with munitions, towed offshore, then sunk at deepwater sites. None of these ships are known to have been disposed at the SF-DODS.

4.5.4.3 Radioactive Waste

Disposal of low-level radioactive waste materials off the coast of San Francisco occurred between 1946 and 1965. Exact coordinates of the actual disposal events are unknown; however, portions of these areas are directly to the west of the SF-DODS. Ocean disposal of radioactive wastes was discontinued around 1965 when land disposal sites were licensed to receive the wastes. In 1970, the United States terminated all ocean disposal of radioactive waste materials.

It is not possible to determine accurately the amount of low-level radioactive wastes disposed by these operations because the characteristics of the waste materials and associated radioactivity were poorly documented. However, the total quantity of radioactive waste materials disposed at all these sites is estimated at 44,500 to 47,500 containers. The wastes included a mix of liquid and solid materials, with a wide variety of chemical and physical properties. The wastes contained an estimated total radioactivity of 14,500 curies, primarily associated with thorium, uranium, transuranic and other activation-produced radionuclides, and mixed fission products with half-lives greater than one year.

Reasons for Selection of SF-DODS as the Designated Deep Ocean Disposal Site

1. Existing and potential fisheries resources within the site are minimal and the proposed site is removed from more important fishing grounds of the continental shelf or the other alternative sites. The SF-DODS was preferred over all the alternative sites by area fishermen's groups.
2. The site supports a lower abundance and biomass of demersal fishes and invertebrates, and a lower abundance and diversity of infaunal invertebrates, compared to alternative sites studied.
3. Potential impacts to surface and mid-water organisms (marine birds, marine mammals, and fishes) are expected to be insignificant at the site compared to the shallower continental shelf areas, including the Farallon Islands located approximately 30 nautical miles landward.
4. Bathymethric and sediment surveys indicate that the site is located in a depositional area with topographic containment features that are likely to retain deposited dredged material.
5. No significant impacts to other resources or amenity areas, such as marine sanctuaries, are expected from site use.
6. Disposal of low-level radioactive wastes and chemical and conventional munitions occurred historically in the vicinity of the site so that cumulative impacts of disposal actions there would be less than at other sites.
7. The SF-DODS comprises an area previously used for disposal of limited volumes of dredged material under Section 103 of MPRSA (U.S. Navy deepening project). Monitoring of the Navy's disposal activities confirmed the site performs as predicted in EPA's Final EIS (USEPA 1993a), and established the feasibility of monitoring and managing this deep, open-ocean site.

The radioactive waste materials were packaged prior to disposal, typically by encapsulation in concrete within 55-gallon drums or in large (1.5 x 2 x 2.5 m), steel-reinforced, concrete "vaults." Reports from the post-disposal surveys at these disposal sites and the testimony of recreational divers, who encountered a package in relatively shallow waters (60 to 165 feet) near the Farallon Islands indicate that the condition of the drums and vaults they encountered varied. Some containers were intact, whereas others had imploded, rupture, or split. Thus, presumably some radioactive waste materials were not completely encapsulated because the packaging was compromised. However, recent surveys in the vicinity of the SF-DODS have failed to detect residual contamination from any source.

4.5.4.4 Pollutants and Historic Impacts Summary

In summary, the SF-DODS is within a general area that has been used for disposal of various materials in the past, including dredged material, military munitions, and low-level radioactive wastes. Compared to the alternative ocean disposal sites evaluated in previous studies, the potential for cumulative effects of dredged material disposal to the overall continental shelf and slope are minimized at this location. Indeed, there may even be a minor, long-term beneficial effect as a result of cleaner (ocean suitable) dredged material being deposited on a previously degraded seafloor (USEPA 1993a). Minimizing the potential for cumulative effects with historic pollutant impacts, relative to other potential locations for an ocean disposal site, was an important factor in the identification of the SF-DODS as the environmentally preferred ocean disposal location, and in EPA's decision to select this site for formal designation in 1994. The reasons for selection of the SF-DODS site, relative to the alternative sites studied by EPA, are summarized in the text box. Table 4.5-1 summarizes the ocean-related resources of concern associated with dredged material disposal.

4.6 REGIONAL SOCIOECONOMIC SETTING

The regional socioeconomic setting describes characteristics of the regional economy of the Bay Area, a nine-county area that includes Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma counties. The relationship of dredging-dependent industries to the regional economy is discussed. The following sections also describe types of costs facing dredgers for dredging and disposing of dredge material, and financing issues that affect dredgers in the Bay Area.

Table 4.5-1. Ocean-Related Resources of Concern

Resource	*Potential Impact*	*Location*
Water Quality	Temporary increase in turbidity	within site boundaries only
	Temporary decrease in dissolved oxygen	within site boundaries only
Fish	Temporary displacement of pelagic and benthic fish	within site boundaries only
Benthos	Smothering or displacement by deposited dredged material	within site boundaries only
	Change in substrate characteristics (grain size, texture, organic carbon content, etc.)	within site boundaries only
Marine mammals	Temporary disturbance from barge/scow traffic and disposal events	en route to, and in vicinity of, disposal site
Marine birds	Temporary disturbance from barge/scow traffic and disposal events	en route to, and in vicinity of, disposal site

4.6.1 Existing Regional Economic Activity

The Bay Area, with a regional population of approximately 6 million people, is one of California's major urban and economic centers. The regional population is projected to grow to approximately 7.5 million, representing a 25 percent increase, by 2010 (ABAG 1993).

The Association of Bay Area Governments (ABAG 1993) estimates that the Bay Area economy produced more than 3 million jobs during 1990. The distribution of the jobs within the Bay Area is shown in Table 4.6-1.

During 1990, approximately 47 percent of the jobs in the Bay Area were located in Santa Clara and Alameda counties. The majority of the total jobs, about 33 percent, were in the services industry. Retail trade and manufacturing industries accounted for 17 percent and 16 percent, respectively, of regional jobs in 1990. The remaining 34 percent of the region's jobs were distributed among the following industry categories: agriculture, forestry, fisheries, mining, construction, transportation, wholesale trade, finance, insurance, real estate, and government.

Table 4.6-1. Existing and Projected Jobs of the San Francisco Bay Region

County	*Actual 1990*	*Projected 2000*	*Projected 2010*	*% Change between 1990 and 2010*
Alameda	617,320	655,090	796,240	29
Contra Costa	305,140	342,160	430,120	41
Marin	102,240	111,390	129,540	27
Napa	47,590	57,610	72,260	52
San Francisco	582,010	595,370	667,570	15
San Mateo	319,120	367,180	393,540	23
Santa Clara	864,110	899,450	1,046,360	21
Solano	119,300	140,480	194,760	63
Sonoma	153,600	190,160	240,990	57
Region	3,110,430	3,358,990	3,971,380	28

Source: ABAG 1993.

ABAG (1993) estimated that Gross Regional Product (GRP) in the Bay Area totaled approximately $182.7 billion in 1990. Estimates by ABAG indicate that real GRP fell by $4.6 billion between 1990 and 1992. The economic slowdown in the Bay Area for this period is attributed to fundamental structural changes in Bay Area industries (e.g., electronic equipment), as well as decreases in overall growth and declines in market share for the affected industries. A full recovery from the economic slowdown for the region is not expected until 1996 to 1997 (ABAG 1993).

Gross exports from the Bay Area in 1985 were valued at $69.9 billion (1990 dollars), representing an increase of almost 20 percent over 1980 levels. About 26 percent of the 1985 exports were electronic-related. By 1990, the continued expansion of the electronic equipment exports contributed to a 14 percent increase in gross exports, which reached approximately $79.4 billion.

4.6.2 Dredging-Dependent Industries and the Regional Economy

The dredging economy is comprised of public and private entities that fund dredging and disposal activities within the Bay Area and rely on dredging new and existing channels and harbors to support business operations. These dredging dependent entities are discussed below.

4.6.2.1 Structure of the Dredging Economy

The Bay Area includes 11 federally authorized and maintained navigation channels extending over 58 miles. Six of these channels are deep-draft channels (30 to 35 feet) and five are shallow-draft channels (6 to 15 feet deep). The COE funds dredging to maintain the depths of federally authorized navigation channels. In addition to federal channels, numerous privately maintained channels and related marine facilities, some of which adjoin federal channels, are located in the Bay Area.

The maintenance of these navigation channels under both public and private sponsorship facilitates maritime activities relying on deep- and shallow-draft channels, and supports marine-based economic activities. The continuation of maintenance dredging (i.e., maintaining the depths of existing channels) in conjunction with new work (i.e., dredging new channels or deepening existing channels) provides the basis for sustained maritime economic activity and seaport viability in the Bay Area.

A review of historic dredging amounts (LTMS 1994k) indicates that the majority of maintenance dredging (on a volume basis) in the Bay Area was conducted under the auspices of the COE for navigation channel maintenance. Historically, approximately 44 percent of the total average annual dredge volume in the Bay Area (6.6 mcy) was removed for general navigation maintenance. Port and military activities required dredging and disposal of about 24 percent and 22 percent, respectively, of the average annual volume. Small dredging projects generated the remaining 10 percent of the average annual volume of dredged materials.

The following sections describe the roles of Bay Area dredgers and discuss historic dredging amounts associated with each dredger. Dredgers have been categorized according to the general size of their dredging projects. For the purposes of this analysis, *major dredgers* are those dredgers that typically initiate projects with dredging depths of 13 feet or more; *small dredgers* are those dredging to channel depths of 12 feet or less. These definitions are based on criterion developed by the Regional Water Quality Control Board.

Definition of Major Dredgers

U.S. ARMY CORPS OF ENGINEERS. The COE is authorized by the Rivers and Harbors Act of 1899, Section 10, to regulate all obstruction to navigation within the navigable waters of the United States. The COE's jurisdiction extends over activities such as diking, filling, and placement of structures in navigable waterways and other areas below mean high water. The COE is also responsible for issuing permits for dredging activities undertaken by other public agencies and private enterprises in waterways of the United States.

The COE contracts with private companies for dredging services as well as operating its own equipment for maintenance of the 11 federally authorized navigation channels in the Bay Area. Historically, annual COE dredging amounts have averaged approximately 2.9 mcy, representing 44 percent of average annual dredging in the Bay Area.

U.S. NAVY. Extensive dredging is required for the maintenance of navigation channels related to the operation of military installations. Naval facilities are situated throughout the Bay Area. Historic dredging records indicate that 22 percent, or 1.4 mcy, of average annual dredging amounts in the Bay Area are dredged to support the operation of military installations.

Five of the eight naval facilities in the Bay Area are scheduled for base closure and conversion to civilian uses. It is uncertain whether converted facilities would engage in marine activities. Even with the provision of some marine services at the converted facilities, it is likely that future dredging amounts generated by new users of these facilities would be less than those generated by military operations.

PORTS. The operation of commercial seaport facilities requires maintenance dredging and, periodically, the deepening of existing channels and harbor facilities to ensure adequate access by client shipping companies. Major Bay Area ports schedule maintenance dredging to accommodate deep-draft vessels calling at their facilities.

COE records indicate that Bay Area ports have historically accounted for 24 percent, or 1.6 mcy, of average annual dredge volumes. The majority of port-related maintenance dredging was performed by the Port of Richmond and the Port of Oakland, with other Bay Area ports dredging relatively small volumes.

FREIGHT AND BULK SHIPPERS. Bulk shippers, such as companies producing oil and petroleum products, maintain and operate marine facilities near petroleum processing plants to facilitate shipment of petroleum products to various market areas. The COE's records of maintenance dredging indicate that five oil companies perform maintenance dredging in the Bay Area. ARCO, Chevron, Exxon, Shell Oil, and Unocal conduct maintenance dredging on an irregular basis. Dredge amounts were classified as small volumes and represent a minor amount of the total average annual dredging in the Bay Area.

Definition of Small Dredgers

Small dredgers include public and private marinas, yacht clubs, piers, shipyards, small oil companies, and utility companies that undertake relatively small dredging projects on channels and harbors with depths of 12 feet or less and volumes of less than 50,000 cubic yards per year on average. A review of COE records of dredging since 1991 indicates that small dredging projects range from less than 1,000 to about 50,000 cy of dredge material per year on average. (Dredging amounts for small dredgers were not separately recorded in COE records for years prior to 1991.) Most of the dredging projects undertaken by small dredgers occur irregularly and are highly variable in volume. Annual total dredge volumes generated by small dredgers over the 1991 to 1993 period ranged from 158,000 to 267,060 cy.

4.6.2.2 Contribution of Dredging-Dependent Industries to the Regional Economy

San Francisco Bay and connected waterways comprise one of the largest natural harbors in the world. Maritime activities supported by the Bay and the adjoining Sacramento-San Joaquin Delta include deep-draft cargo shipping, military facility operations, commercial fishing, ship repair, recreational fishing, water-based transportation (ferries), recreational boating, and tourism.

The maritime trade and associated activities account for a significant contribution to the overall economic conditions of the Bay and Delta region. Specific operations supporting cargo-related maritime trade include vessel, port, and inland transportation activities; commercial and financial maritime services; and crew expenditures. The economic scale of these commercial activities was analyzed as part of the LTMS program in a study conducted by Ogden Beeman & Associates (LTMS 1990a). The following discussion relies extensively on the results of that study.

Maritime facilities and services found in the Bay Area include government maritime services, major ports to accommodate the deep-draft shipping industry, recreational boating, commercial and recreational fishing, passenger boats, and ship repair. These activities generate employment opportunities and produce revenues that contribute to the regional economy.

Table 4.6-2 presents a summary of the commercial activities and associated economic values for the Bay Area. The estimates in Table 4.6-2 indicate that maritime industries and services, excluding the commercial fishing industry, contribute approximately $7.5 billion in revenues and 94,500 in jobs to the regional economy. These revenues represented 4.1 percent of the Bay Area's estimated GRP and 3.0 percent of its jobs in 1990.

Table 4.6-2. Summary of Maritime Industry Economic Activity

Maritime Activity	*Revenues ($000s)*	*Employment*
Cargo Movement	2,646,757	30,060
Recreational Boating	168,444	N/A
Ferries and Tourism	60,925 [a]	N/A [b]
Government Services	4,584,428 [c]	63,696
Shipbuilding and Repair	57,912	771
TOTALS	7,518,466	94,527

Notes: a. Includes cruise line tourist spending.
b. Passengers served totalled about 4.6 million.
c. Combined government services: U.S. Navy, U.S. Army Corps of Engineers, U.S. Coast Guard, and U.S. Customs Bureau.

Source: LTMS 1990a.

The following sections summarize the contributions of dredging-dependent industrial sectors to the regional economy.

Federal Government

The government provides maritime related services through the U.S. Navy, the U.S. Coast Guard, the COE, and the U.S. Customs Bureau. Of these, the U.S. Navy has been one of the most significant maritime employers in the Bay/Delta region. Through payroll and operating funds, the service spent nearly $1.4 billion for operations in the region. Approximately $418 million of this amount was spent for net salaries of 5,500 active duty sailors and Marines, and 14,500 civilian employees. Another $982 million was allocated annually for Bay Area commands and organizations. The extent of continued U.S. Navy expenditures in the Bay Area is currently uncertain due to reductions in national defense spending on a nationwide basis.

The U.S. Coast Guard, the COE, and the U.S. Customs Bureau also provide employment and annual revenues for the Bay Area economy. These government organizations together supported about 869 jobs and infused the local economy with $21.5 million.

Ports

The ports of the San Francisco Bay and its adjoining Delta are a major center for foreign trade. The Ports of Oakland, San Francisco, Redwood City, and Richmond are situated on San Francisco Bay; the Sacramento and Stockton ports are located in the Sacramento-San Joaquin Delta. These maritime trade facilities include approximately 150 piers, wharves, and docks in the area. Cargo tonnage and the number of arrivals at Estuary ports from 1970 to 1989 is shown in Figure 4.6-1. The region's ports handled foreign trade valued at approximately $34 billion in 1992 (USACE and Port of Oakland 1994).

PORT OF OAKLAND

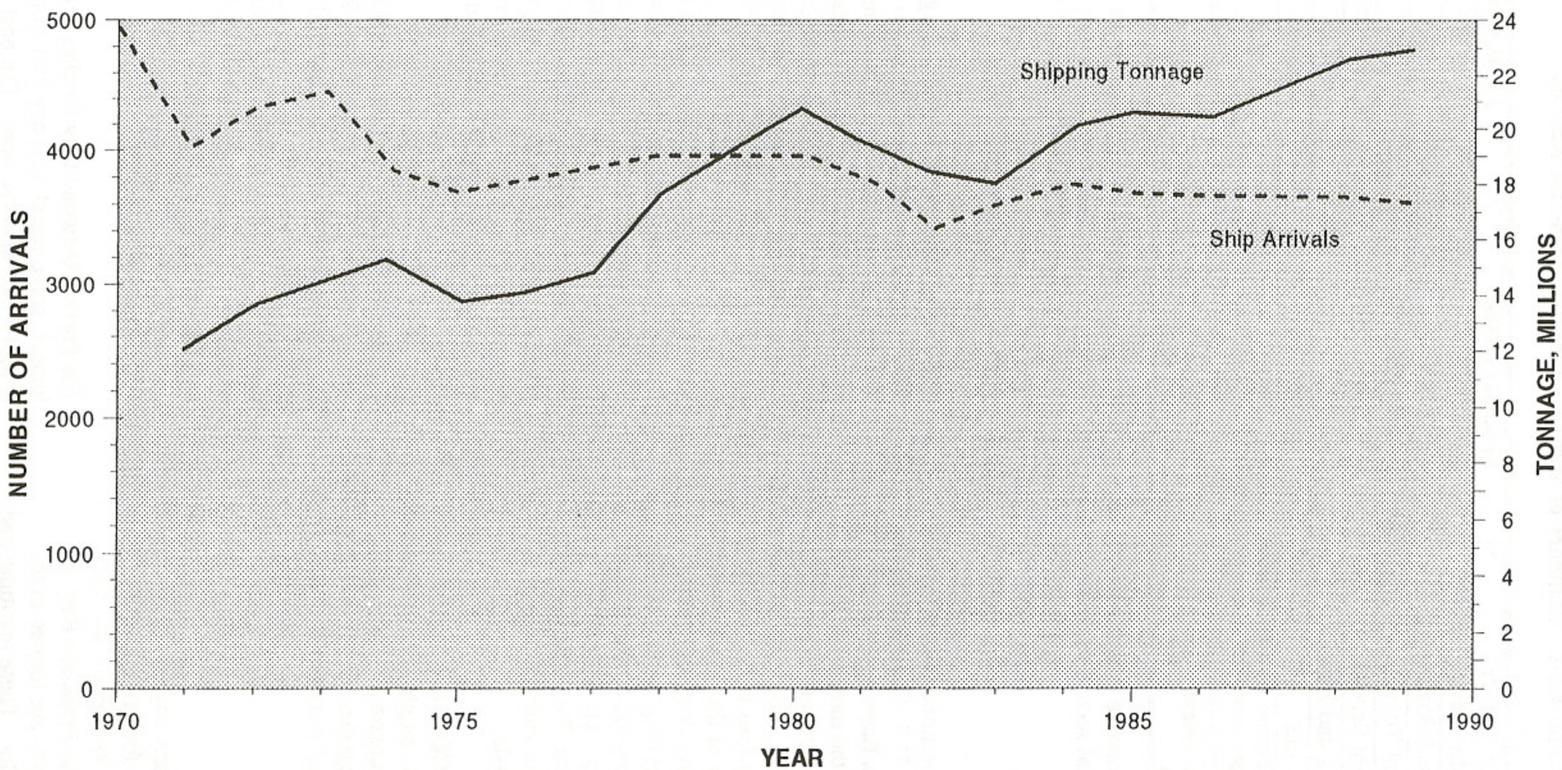
The Port of Oakland is the fourth largest of the West Coast ports in loaded container cargo volume, and the fifth largest port in the nation in terms of cargo handled. The port has over 550 acres of marine terminal facilities, 27 deepwater berths, and 29 container cranes. Thirty-two shipping lines call at the port (USACE and Port of Oakland 1994).

The Port of Oakland generated about $1.2 billion in business revenue from maritime operations in 1991. The port also provided 6,700 direct jobs and 2,900 induced jobs, generating a total of $429.6 million in personal income. Direct jobs are those jobs directly associated with the movement of cargo through the port, while induced jobs result from support services to those with direct jobs (USACE and Port of Oakland 1994).

The Port of Oakland handled about 15.8 million revenue tons in 1991. Records for 1991 show that there were 1,405 vessel calls and 550 shared vessel calls. The port also served 300 barges, primarily for the transport of bunker fuel. About 669,000 containers passed through the port in 1991 (USACE and Port of Oakland 1994).

PORT OF REDWOOD CITY

The Port of Redwood City handles primarily cement, lumber, scrap metal, and dry bulk commodities for firms located near the port. The port also has facilities for handling liquid bulk, petroleum products, and general cargo. Facilities include five wharves.



Note: Point of comparison: 1989 Shipping tonnage for Port of Los Angeles/Long Beach = 71.6 million tons *Source:* Pacific Maritime Association (1990)

Figure 4.6-1. Total Revenue Tonnage of Cargo Handled at Estuary Ports and Number of Arrivals

The LTMS (1990a) study estimated that Port of Redwood City revenues totaled approximately $45.1 million. An estimated 659 jobs are directly and indirectly generated by port activities.

The total tonnage handled at the Port of Redwood City in 1990 was 390,000 metric tons. This total included 278,000 tons of dry bulk goods, 3,000 tons of liquid bulk, and 109,000 tons of general cargo.

PORT OF RICHMOND

The Port of Richmond includes seven city-owned terminals on a 35-foot shipping channel. These facilities handle commodities such as petroleum products, chemicals, petrochemicals, vegetable oils, molasses, vehicles, steel and wood articles, and containerized articles. Two concrete finger piers are available for vessel lay-ups, with five dry docks for lay-ups.

The Port of Richmond also includes 11 privately owned terminals. The facilities primarily handle bulk liquid products, as well as scrap metal, various dry-bulk, and break-bulk commodities. Chevron USA operates an extensive petroleum shipping and terminal operation at its own facilities on a portion of the City's waterfront.

In 1991, 22 million tons of cargo moved through the port on 2,039 vessels. Auto operations at the Point Potrero Marine Terminal handled over 128,000 vehicles for the year.

PORT OF SAN FRANCISCO

The Port of San Francisco is the nation's 12th largest port. The port's marine facilities cover 145.1 acres and include cargo handling for containers, roll-on roll-off goods, and break-bulk commodities. The port operates eight shoreside container cranes along a 40-foot water depth and provides full on-dock rail service. Other facilities at the port include two newsprint terminals, an import auto facility accommodating over 1,500 autos, a 2-million bushel grain elevator, a cotton warehouse, and various other specialized handling areas. Maritime industries other than cargo handling also provide revenue to the Port of San Francisco. Ship repair and the cruise industry together generated over $3 million in port revenue. In 1991, the port held a 21 percent share of the Bay Area international liner market.

Commercial Fishing Industry

The continental shelf and slope off San Francisco support a range of commercial fisheries. The principal market species in this region include Dungeness crab, market squid, salmon, tuna, flatfishes, a variety of rockfishes, thornyheads, and sablefish. Within the entire San Francisco region (from Point Arena to Point San Pedro, offshore to a distance of 200 nautical miles) some of the most productive commercial fisheries areas are in the Gulf of the Farallones. The estimated value of all major commercial fisheries within the San Francisco region in 1986 totaled over $23.6 million (USEPA 1993a).

The Bay Area commercial fishing fleet consists of approximately 1,100 vessels. The San Francisco port vicinity is the base for the majority of the commercial and charter fishing industries in the Bay Area; Oakland and Sausalito provide the majority of berths for the remaining fleet.

Recreation Industry

A variety of recreational uses depend on having access throughout the San Francisco Bay and its associated waterways. Recreational boating is available from approximately 65 public and private marinas in the Bay Area. These facilities provide about 19,800 slips throughout the region. These regional marina facilities generated approximately $168.4 million (1990 dollars) in revenues for the Bay Area (LTMS 1990a).

The economic effects of marina operations are substantial for the Bay Area. Facilities and operations encompass berth rentals, dry storage, and other sales. Direct and indirect revenues totaled approximately $83.0 million for 1990. Recreational fishing is also supported by charter and individual boats docked at public and private marinas throughout the Bay Area.

Tourism and Transportation

Ferry and tourist boat operations in the Bay include Golden Gate Bridge Ferries, Red & White Fleet, Blue & Gold Fleet, and Hornblower Yachts. Revenues attributable to passenger ferries and tourist vessels in the central Bay Area were estimated to total $26.5 million in 1988, providing approximately 4.5 million passenger trips. A smaller amount of revenue, about $1.8 million, resulted from ferry operations in the north Bay Area (Vallejo terminal on Mare Island Channel), serving approximately 233,767 passengers.

Cruise ship calls also produce revenues through passenger spending. Benefits from passenger spending attributable to cruise ships were estimated to be $25.2 million in 1986.

Ship Building and Repair Industry

Ship building and repair services in the Bay Area represent a $50.8 million regional industry. For most companies, the U.S. Navy's ship building and repair constitutes the largest portion of total revenues (LTMS 1990a).

4.6.3 Types of Costs faced by the Dredging Community

Dredging and disposal costs depend on a wide variety of factors. This section explains the key factors and outlines how these factors generally affect dredging and disposal costs.

Dredging projects typically involve a number of discrete activities that can generally be grouped into activities required for dredging and placing materials at disposal sites, and activities required for developing and managing disposal sites. The activities can be summarized as follows:

- *Testing:* Sediment evaluation and testing to determine its suitability for disposal
- *Dredging and Placement:*
  - Dredging: mobilizing/demobilizing dredge equipment and dredging a project site
  - Transport: hauling dredged material to a disposal or rehandling site and placing dredged material at the site
- *Rehandling* (for certain disposal sites)
  - Drying dredged material at a rehandling facility, excavating the dried material, and hauling the material to a final disposal site
- *Site Development and Management*:
  - Initial site preparation (e.g., initial site acquisition, environmental assessments and mitigation, planning, design, engineering, construction, and construction management)
  - Site operations and maintenance
  - Site monitoring

The costs for each activity vary among the placement environments based on factors such as transport distance to disposal sites, site preparation requirements, and disposal site operations and maintenance requirements. This section will define and explain the various factors that affect these costs.

In general, unit costs for small dredger work differ from larger new work and maintenance projects primarily because of differences in economies of scale. Small dredger work projects, which include both new and maintenance dredging, usually involve smaller quantities of dredge material. Unit costs for mobilizing equipment and dredging and transporting material are likely to be higher than maintenance dredging because costs are spread over smaller volumes of dredged material. In addition, the limited depths of small projects often necessitate that shallow-draft, lower-volume barges be used. The resulting increase in the number of round trips to the disposal site (per unit volume of dredged material) can also drive up unit costs for small dredge projects.

4.6.3.1 Testing Costs

Sediments are usually sampled and tested prior to dredging to determine the existence of NUAD material. Testing costs include sediment sampling, extraction, analysis, and documentation. Project-specific testing costs vary widely depending on the degree of existing sediment quality information, project size, project locations, special analyses, list versus contract rates for laboratory work, sampling techniques (e.g., pipe versus vibracore), the need for reference samples, and other project variables.

Testing costs also vary among the different placement options. Disposal environments have different testing requirements that govern the tests needed, the number of tests required per dredged volume, and the number of samples — all factors that affect testing costs. For instance, the current tests required for in-Bay disposal (PN 93-2) are significantly less expensive than those for ocean disposal (Green Book). The forthcoming Inland Testing Manual, however, will provide in-Bay testing guidelines similar to those governing ocean testing. Testing costs for ocean disposal will continue to be more expensive, however, due to the longer travel distance to the ocean site for reference sampling. The tests required for upland disposal are less expensive than those for ocean or in-Bay.

The costs for sediment testing, however, depend on the quantity of material dredged. For the most part, per volume unit costs for testing decline as volume increases. Testing guidelines dictate a minimum number of samples and tests that must be conducted, which makes the unit cost significantly higher for very small projects. For instance, PN 93-2 requires one test for dredge volumes between 5,000 and 20,000 cy, so the unit cost for the 5,000-cy project will be four times more than for the 20,000-cy project.

4.6.3.2 Dredging and Placement Costs

The following key factors define the costs for dredging and placement:

- Volume of material,
- Type of material,
- Haul distance,
- Depth of access channel,
- Placement environment and technique,
- Ownership costs, and
- Operating costs.

Per unit volume costs associated with disposal (e.g., disposal site preparation, operations, maintenance, and monitoring) do not generally depend on the factors listed above; these costs may be similar across the various dredging types for the same disposal sites but would vary across the various placement environments. These costs are described below.

All of these factors dictate the type of equipment that will be used for dredging and placement. Different equipment configurations have different costs and production rates, which affect the total cost of a project.

4.6.3.3 Rehandling Costs

Transportation of dredged material to a landfill or other UWR disposal site often involves a two-step process. Materials are first transported by barge from the dredge site to a rehandling facility, where wet material is allowed to dry. Placement costs for offloading to the rehandling facility are likely to be similar to offloading to similar UWR sites. Dry dredge material is then excavated from the rehandling facility, trucked to the final placement site, and then offloaded. Rehandling costs include the cost to rent/lease the volume for drying at the rehandling facility, as well as the cost of subsequent excavation, loading, transportation, and offloading. Factors affecting the rehandling cost are the cost of loading and unloading the dry material and the haul distance to the final placement site.

4.6.3.4 Site Development and Management Costs

Site development and management costs can be categorized according to costs associated with the initial preparation of disposal sites, ongoing site operation and maintenance costs, and ongoing site monitoring costs.

Site preparation costs include land acquisition costs; construction costs; and engineering, design, environmental, planning, and construction management costs. They also include public agency staff time spent on permit review and approval. These costs are not necessarily borne by the site's developers or the dredging community, but they represent a real cost to government.

Under the current regulatory framework, UWR sites have significantly higher site preparation and development costs than ocean or in-Bay sites. Habitat restoration and dredged material rehandling sites could incur significant land acquisition costs not associated with aquatic disposal sites. Acquisition costs depend on area land values and alternative uses for the land. Several of the most feasible sites currently under consideration (e.g., Hamilton Air Base, Mare Island) are publicly owned, potentially reducing the cost of site acquisition. There would be no acquisition costs, however, for rehabilitation of existing levees. In most cases, site construction and permitting costs also are likely to be higher for upland sites than for aquatic disposal, as upland sites typically require greater engineering, design, and construction work. Construction costs also vary among upland sites.

Site development costs do not necessarily vary between the dredging work categories, depending on the intended use of the site. UWR sites may be developed for the exclusive use of a single project or a specific group of projects, or may receive materials from many projects. It is not likely that small dredgers will develop an upland site as part of a small dredging project. If the site is developed by a public or non-profit entity (as in the case of Sonoma

Baylands), the dredging community may not bear the cost of land acquisition and site development, but rather would face only the incremental cost of disposing material at the site instead of in the Bay or ocean.

Ongoing site operations and maintenance costs vary depending on the disposal site. Ocean and in-Bay sites have no ongoing operations costs, other than monitoring activities described below. Site operations and maintenance cost for UWR sites include a wide variety of activities: upkeep of buildings or structures on site; dike and levee elevation and maintenance; engineering and equipment services for managing placed material and executing site management plans; and engineering and equipment services to ensure proper drainage and water management (LTMS 1995d). These costs are site specific, and vary widely between sites. In general, site management and maintenance costs do not vary by work category, unless a site is being managed for a particular project or group of projects.

Following the placement of dredged material, disposal sites may require ongoing monitoring to detect potential environmental effects. In general, monitoring for aquatic disposal will include water quality, turbidity, and the effects on aquatic biota. Monitoring plans for UWR sites will depend on the type of site. Restoration of tidal wetlands could require monitoring for effects on water quality and biota, as well as the development of the site itself (e.g., sedimentation rate at the site, channel formation, revegetation, and plant succession). Monitoring at levee rehabilitation and rehandling sites typically would involve monitoring runoff for dissolved metals, salinity, and suspended solids, among others (see Chapter 3). Rehandling facilities may also need to monitor for potential groundwater contamination.

Monitoring costs for UWR are very dependent on both the placement environment and the specifications of a particular disposal site. The level and complexity of the monitoring, and therefore its cost, depends on the characteristics of the particular site and the surrounding environment, existing structures (e.g., drains and runoff channels), regulations governing the particular region, and the presence of endangered species or other biota of concern. For instance, concern about groundwater contamination in the upper Delta may lead to more stringent monitoring for levee rehabilitation projects than would be required for tidal wetland restoration in the Bay.

4.6.4 Existing Financing Structures for Dredging and Disposal

The following discussion of existing financing policies and overview of cost-sharing policies and issues facing dredgers in the Bay Area is a summary of information contained in a financing background study that was prepared for the LTMS planning process (LTMS 1995b).

The initial authority for dredging was provided by the River and Harbors Act of 1899. Until 1986, the federal government generally funded 100 percent of the costs for all federal channel dredging programs with local non-federal sponsors assuming all costs for land, rights-of-way, and easements. In 1986, Congress enacted the Water Resources Development Act (WRDA) of 1986. This legislation established specific requirements for local sponsor cost sharing.

For new dredging projects (new work) on federal channels, including deepening of channels and harbors, the legislation generally requires local, non-federal sponsors to pay 25 percent of the costs; the federal share of the cost is 75 percent. Such cost sharing usually is limited to the portion of construction costs that applies to the general navigation features (GNF) of the project and excludes other project costs.

For maintenance dredging projects (maintenance work) on existing and new federal channels, the federal share of costs generally remained at 100 percent, except for channels more than 45 feet deep. For depths of more than 45 feet, the federal government pays only 50 percent of operations and maintenance costs.

The 75 percent federal share of GNF costs for new work projects is based on the costs of the least-cost environmentally acceptable alternative, regardless of which disposal alternative is chosen. The non-federal sponsor usually pays 100 percent of the cost beyond that associated with the least-cost alternative.

The Water Resources Development Act of 1992 modified cost sharing policies by providing general program authority for the COE, with 25 percent non-federal cost sharing, to undertake environmental projects, such as habitat creation and wetlands restoration, in connection with dredging for construction, operation, or maintenance of an authorized project. This provision allows the COE to consider the value of creating such environmental assets on a qualitative basis when considering the least-cost alternative for cost-sharing purposes.

The following sections describe existing financing conditions for major and small dredgers in the Bay Area.

4.6.4.1 Major Dredgers Financing

U.S. Army Corps of Engineers

The federal government funds 100 percent of the operations and maintenance work on existing federal channels and harbors used by commercial navigation when dredging depths are 45 feet or less. For depths more than 45 feet, the federal government funds 50 percent of the operations and maintenance costs, with local sponsors financing the remaining 50 percent of costs. Funding for maintenance dredging activities generally excludes any costs incurred by the dredger associated with upland/wetland disposal of dredged materials. Funding for new work is cost-shared according to WRDA 1986.

U.S. Navy

The costs for dredging navigation channels related to the operation of military facilities are funded by the federal government.

Ports

The ports in the Bay Area undertake maintenance dredging projects that are not a part of federally authorized and funded projects. Permits are required and the ports pay 100 percent of these costs.

Freight and Bulk Shippers

The availability of federal funding for new work and maintenance dredging for these dredgers is similar to the conditions described for the ports. The companies undertake both federally authorized and non-federally funded projects.

4.6.4.2 Small Dredgers Financing

Small dredging jobs are accomplished under appropriate permitting procedures and are funded by the dredgers.

Some minor dredging projects or facilities originally constructed as federal projects receive federal cost-sharing funds for their projects. For example, a recent maintenance dredging project undertaken by the San Leandro Marina was a federally authorized project.

4.7 AIR QUALITY

Air quality in the immediate LTMS activity areas and in the surrounding regional environment would be affected by emissions from equipment associated with the proposed dredging, transportation, and disposal activities. The LTMS dredging areas and disposal sites are located mainly in the San Francisco Bay Area Air Basin (SFBAAB). However, operations occurring in the Delta region would also potentially affect the Sacramento and Solano County portions of the Sacramento Valley Air Basin (SVAB) and/or the San Joaquin County portion of the San Joaquin Valley Air Basin (SJVAB). The SFBAAB is composed of the counties of Santa Clara, San Mateo, San Francisco, Marin, Napa, Contra Costa, and Alameda, along with the southeast section of Sonoma and the southwest section of Solano counties. The boundaries of the SFBAAB, SVAB, and SJVAB are shown in Figure 4.7-1.

General descriptions of the air quality resource and potentially affected region of influence are provided in this section. Subsequent sections discuss the existing climate and meteorology of the region; regulatory environment; baseline air quality concentrations; and baseline emissions within the SFBAAB, and the potentially affected portions of the SVAB and SJVAB.

Description of Resource

Air quality at a given location can be described by the concentrations of various pollutants in the atmosphere. Units of concentration are generally expressed in parts per million (ppm) or micrograms per cubic meter ($\mu g/m^3$). The significance of a pollutant concentration is determined by comparing the concentration to an appropriate federal and/or state ambient air quality standard. The standards represent the allowable atmospheric concentrations at which the public health and welfare are protected and include a reasonable margin of safety to protect the more sensitive individuals in the population. Federal standards, established by the EPA, are termed the National Ambient Air Quality Standards (NAAQS). The NAAQS are defined as the maximum acceptable concentrations that may not be exceeded more than once per year, except the annual standards, which may never be exceeded. The state standards, established by the California Air Resources Board (ARB), are termed the California Ambient Air Quality Standards (CAAQS). The CAAQS are defined as the maximum acceptable pollutant concentrations that are not to be equaled or exceeded. The NAAQS and CAAQS are presented in Table 4.7-1. The pollutants of main concern that are considered in this analysis include ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and particulate matter smaller than 10 microns in diameter (PM_{10}).

Region of Influence

Identifying the specific region of influence (ROI) for air quality requires knowledge of the types of pollutants being emitted, the emission rates and release parameters of the pollutant source (e.g., release temperature, area of release, release height), the source proximity to other pollutant sources, and local and regional meteorological conditions. The ROI for emissions of inert pollutants (all pollutants other than O_3 and its precursors) is generally limited to a few miles downwind from a source. Thus, for the emission of inert pollutants from LTMS-related dredging and transport activities, the ROI is limited to the immediate waters and coastal areas of San Francisco Bay, the Central Bay, San Pablo Bay, Suisun Bay, the Delta, and the Pacific Ocean. Emissions of inert pollutants from equipment associated with disposal activities may affect areas farther inland in the vicinity of upland disposal sites and along the sediment haul routes to those sites.

The ROI for O_3 can extend much farther downwind than for inert pollutants. Ozone is a secondary pollutant formed in the atmosphere by photochemical reactions of previously emitted pollutants, or precursors. Ozone precursors are mainly the reactive organic gas (ROG) portion of volatile organic compounds (VOC) and oxides of nitrogen (NO_x). In the presence of solar radiation, the maximum effect of ROG and NO_x emissions on O_3 levels usually occurs several hours after they are emitted and many miles from the source. Ozone and O_3 precursors transported from other regions can also combine with local emissions to increase local O_3 concentrations. Therefore, the ROI for O_3 may include much of the SFBAAB and portions of the SVAB and/or SJVAB.

4.7.1 Climate and Meteorology

The climate of the LTMS project area can be classified as Mediterranean, characterized by cool, dry summers and mild, wet winters. The major influence on the regional climate is the Eastern Pacific High, a strong persistent anticyclone. Seasonal variations in the position and strength of this system are a key factor in producing weather changes in the area.

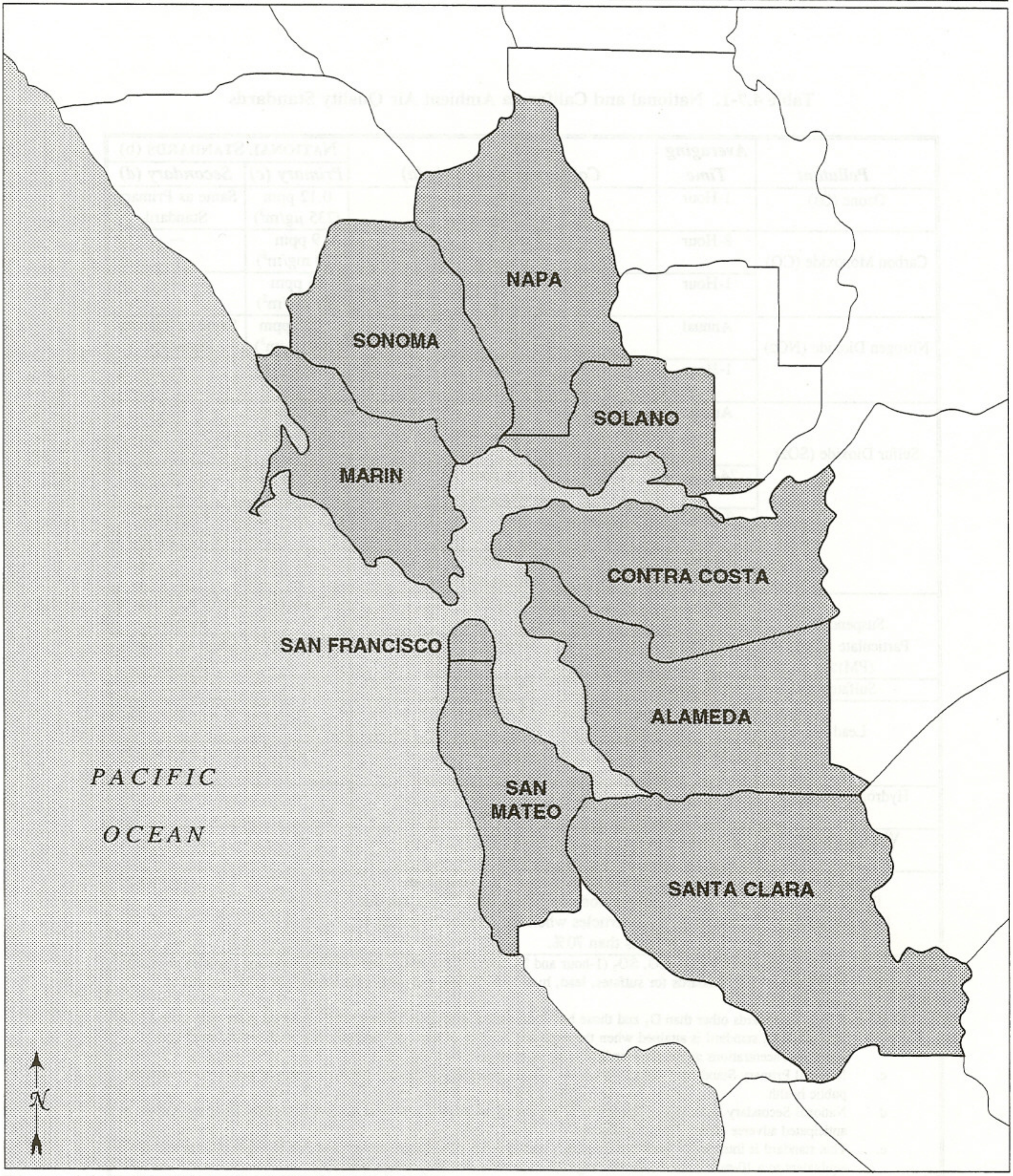


Figure 4.7-1. LTMS Area of Air Quality Impact

Table 4.7-1. National and California Ambient Air Quality Standards

Pollutant	*Averaging Time*	*California Standards (a)*	NATIONAL STANDARDS (b) *Primary (c)*	NATIONAL STANDARDS (b) *Secondary (d)*
Ozone (O_3)	1-Hour	0.09 ppm (180 $\mu g/m^3$)	0.12 ppm (235 $\mu g/m^3$)	Same as Primary Standard
Carbon Monoxide (CO)	8-Hour	9 ppm (10 mg/m^3)	9 ppm (10 mg/m^3)	—
	1-Hour	20 ppm (23 mg/m^3)	35 ppm (40 mg/m^3)	—
Nitrogen Dioxide (NO_2)	Annual	—	0.053 ppm (100 $\mu g/m^3$)	Same as Primary Standard
	1-Hour	0.25 ppm (470 $\mu g/m^3$)	—	—
Sulfur Dioxide (SO_2)	Annual	-	0.03 ppm (80 $\mu g/m^3$)	—
	24-Hour	0.04 ppm (105 $\mu g/m^3$)	0.14 ppm (365 $\mu g/m^3$)	—
	3-Hour	—	—	0.5 ppm (1,300 $\mu g/m^3$)
	1-Hour	0.25 ppm (655 $\mu g/m^3$)	—	—
Suspended Particulate Matter (PM_{10})	Annual	30 $\mu g/m^3$	50 $\mu g/m^3$	Same as Primary Standard
	24-Hour	50 $\mu g/m^3$	150 $\mu g/m^3$	Same as Primary Standard
Sulfates	24-Hour	25 $\mu g/m^3$	—	—
Lead	30-Day	25 $\mu g/m^3$	—	—
	Quarterly	—	1.5 $\mu g/m^3$	Same as Primary Standard
Hydrogen Sulfide	1-Hour	0.03 ppm (42 $\mu g/m^3$)	—	—
Vinyl Chloride	24-Hour	0.010 ppm (26 $\mu g/m^3$)	—	—
Visibility Reducing Particles (e)	8-Hour (10 A.M.. to 6 P.M..)	In sufficient amount to produce an extinction coefficient of 0.23 per km due to particles when the relative humidity is less than 70%.	—	—

Notes:
a. California standards for O_3, CO, SO_2 (1-hour and 24-hour), NO_2, PM_{10}, and visibility reducing particles are not to be exceeded. The standards for sulfates, lead, hydrogen sulfide, and vinyl chloride are not to be equaled or exceeded.
b. National standards other than O_3 and those based on annual averages, are not to be exceeded more than once a year. The O_3 standard is attained when the expected number of days per calendar year with a maximum hourly average concentrations above the standard is equal to or less than one.
c. National Primary Standards: The levels of air quality necessary, with an adequate margin of safety, to protect the public health.
d. National Secondary Standards: The levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects from a pollutant.
e. This standard is intended to limit the frequency and severity of visibility impairment due to regional haze and is equivalent to a 10-mile nominal visual range when relative humidity is less than 70%.

The Eastern Pacific High attains its greatest strength and most northerly position during the summer, when it is centered west of northern California. In this location, the High effectively shelters California from the effects of polar storm systems from the North Pacific. Due to the large-scale atmospheric subsidence associated with the High, an elevated temperature inversion often occurs along the West Coast. The base of this inversion is usually located from 1,000 to 3,000 feet above mean sea level, depending on the intensity of subsidence and the prevailing weather condition. Vertical mixing is often limited to the base of the inversion, trapping air pollutants in the lower atmosphere. Marine air trapped below the base of the inversion is often condensed into fog and stratus clouds by the cool Pacific Ocean. This condition is typical of the warmer months of the year from roughly May through October. Stratus usually forms offshore and moves into coastal areas during the evening hours. As the land heats up the following morning, the clouds will burn off to the immediate coastline, then move back onshore the following evening.

As winter approaches, the High begins to weaken and shift to the south, allowing polar storms to pass through the region. These storms produce periods of cloudiness, strong shifting winds, and precipitation. The number of days with precipitation can vary greatly from year to year, resulting in a wide range of annual precipitation totals. Storm conditions are usually followed by periods of clear skies, cool temperatures, and gusty northwest winds as the storm systems move eastward. Annual precipitation totals for the Oakland International Airport ranged from 9 to 30 inches during a 40-year period of record (1941 through 1980), with an annual average of 17.77 inches (National Oceanic and Atmospheric Administration [NOAA] 1980). Meteorological data from this station are considered generally representative of regional conditions throughout the LTMS area. Precipitation would be somewhat lower along the coast and within the San Francisco Bay waters and would increase northward and inland toward higher, more mountainous terrain. About 90 percent of rainfall in the region occurs from November through April.

The average high and low temperatures at the Oakland International Airport in July are 71.1°F and 55.5°F, respectively. January average high and low temperatures are 55.6°F and 40.7°F. Extreme high and low temperatures recorded from 1941 through 1980 were 107.0°F and 23.0°F, respectively (NOAA 1980). Temperatures within and near the Bay do not fluctuate greatly, due to the moderating effect of the Pacific Ocean. Temperatures would generally increase and extremes would be greater farther inland, away from the ocean.

The proximity of the Eastern Pacific High and a thermal low pressure system in the Central Valley region to the east produces air flow generally from the west to northwest along the central and northern California coast for most of the year. The persistence of these breezes is a major factor in minimizing air quality impacts from almost 6 million people that live in the region. As this flow is channeled through the Golden Gate Bridge, it branches off to the northeast and southeast, once inside the Bay. As a result, winds often blow from the northwest in the South Bay, from the southwest in the Central Bay, then from the west as winds flow through the Suisun Bay and Delta regions towards the San Joaquin Valley. Nocturnal and wintertime land breezes tend to blow in the opposite direction of this pattern. These land breezes may extend many miles offshore during the colder months of the year until daytime heating reverses the flow back onshore.

During the fall and winter months, the Eastern Pacific High can combine with high pressure over the Great Basin to produce extended periods of light winds and low-level temperature inversions. This condition frequently produces poor atmospheric dispersion that results in degraded regional air quality. Ozone standards traditionally are exceeded when this condition occurs during the warmer months of the year.

4.7.2 Applicable Air Quality Regulations

4.7.2.1 Federal Regulations

Clean Air Act of 1969 (42 U.S.C. Section 7401 et seq.)

Air quality regulations were first promulgated with the Clean Air Act (CAA) of 1969. The CAA is intended to protect the Nation's air quality by regulating emissions of air pollutants. The CAA is applicable to permits and planning procedures related to dredged material disposal onshore and within the territorial sea. The territorial sea is defined as waters 3 miles seaward of the nearest shoreline. For bays or estuaries, the 3-mile territorial sea begins at a baseline drawn across the opening of the water body. Section 118 of the CAA (42 U.S.C. 7418) requires that all federal agencies engaged in activities that may result in the discharge of air pollutants comply with state and local air pollution control requirements. In addition, Section 176 of the CAA (42 U.S.C. 7506) prohibits federal agencies from engaging in any activity that does not conform to an approved State Implementation Plan (SIP).

This act established the NAAQS and delegated enforcement of air pollution control to the states. In California, the ARB has been designated as the agency responsible for regulating air pollution sources at the state level. The ARB, in turn, has delegated the responsibility of regulating stationary emission sources to local air pollution control or management districts which, for LTMS activity, are the Bay Area Air Quality Management District (BAAQMD), the Sacramento Metropolitan Air Quality Management District (SMAQMD), and the San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD).

The NAAQS (shown in Table 4.7-1) include both primary and secondary standards for various pollutants. Primary standards are mandated by the CAA to protect the public health, while secondary standards are intended to protect the public welfare from any known or anticipated adverse effects of a pollutant, such as materials soiling, vegetation damage, and visibility impairment.

The CAA states that all applicable federal and state ambient air quality standards must be maintained during the operation of any emission source. The CAA also delegates to each state the authority to establish their own air quality rules and regulations. State adopted rules and regulations must be at least as stringent as the mandated federal requirements. In states where the NAAQS are exceeded, the CAA requires preparation of a SIP that identifies how the state will meet the standards within the time frame mandated by the Clean Air Act Amendments of 1990.

The Clean Air Act Amendments of 1990 (42 U.S.C. 7401 et seq., as amended by P.L. 101-549)

The Clean Air Act Amendments of 1990 (1990 CAA) established new nonattainment classifications, new emission control requirements, and new compliance dates for areas presently in nonattainment of the NAAQS, based on upon the design day value. The design day value is the fourth highest pollutant concentration recorded in a 3-year period. The requirements and compliance dates for reaching attainment are based on the nonattainment classification. The classifications and compliance dates are shown in Table 4.7-2.

Table 4.7-2. Federal Attainment Schedule

Pollutant/Classification	*Design Day Value Concentration (a) (ppm)*	*Compliance Date*
Ozone (b)		
Marginal	0.121-0.138	November 15, 1993
Moderate	0.138-0.160	November 15, 1996
Serious	0.160-0.180	November 15, 1999
Severe	0.180-0.280	November 15, 2005
Severe	0.190-0.280	November 15, 2007 (c)
Extreme	$\geq$0.280	November 15, 2010
Carbon Monoxide (d)		
Moderate	9.1-16.4	December 31, 1995
Serious	$\geq$16.5	December 31, 2000
PM_{10} (e)		
Moderate	--	February 8, 1997
Serious	--	December 31, 2001

Notes:
a. The design day value is the fourth highest pollutant concentration recorded in a 3-year period.
b. 42 USC 7511.
c. 42 USC 7511(a)(2)
d. 42 USC 7512.
e. 42 USC 7513.

Source: Clean Air Act Amendments, November 1990.

One of the requirements established by the 1990 CAA was an emission reduction amount that would be used to judge how progress toward attainment of the O_3 standards would be measured. The 1990 CAA requires areas in nonattainment of the NAAQS for ozone to reduce basinwide VOC emissions by 15 percent for the first 6 years and by an average of 3 percent per year thereafter until attainment is reached. Control measures